

EROSION RATES FOR POLYMERS MEASURED ON LDEF

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Experiment A0114

- Polymers measured:

Aromatic polyimide (Kapton - H film)

Polyamide (Nylon)

Polytetrafluoroethylene (PTFE)

Polyethylene

Polystyrene

Polyvinyltoluene (PVT)

Polymethylmethacrylate (PMMA, Lucite)

EROSION DEPTHS AND RATES FOR POLYMERS MEASURED ON LDEF

EXPERIMENT A0114 (UAH)

All data from samples on Row 9 (leading edge -8 deg.)

Polymer	Erosion Depth ⁺ (μm)	Reaction Rate [*] ($\text{cm}^3 \text{ atom}^{-1}$)
Kapton	260 ± 5	2.89 ± 0.06
Nylon	253 ± 19	2.8 ± 0.2
Polystyrene	375 ± 15	4.17 ± 0.17
PVT	396 ± 27	4.4 ± 0.3
PMMA	566 ± 28	6.3 ± 0.3
Polyethylene	357 ± 21	3.97 ± 0.23
PTFE	33.5 ± 5	0.37 ± 0.06

* Assuming an LDEF fluence for row 9 of $9.0 \times 10^{21} \text{ atoms cm}^{-2}$

+ Errors quoted in parenthesis (except for Kapton) are simply the RMS roughness of the exposed area. This is usually much rougher than the unexposed.

**COMPARISON OF EROSION YIELDS FROM LDEF
EXPERIMENT A0114 WITH PREVIOUS DATA
FROM STS-8 AND STS-41G**

Material	Erosion Yields [†] ; cm ³ (oxygen atom) ⁻¹	
	LDEF Value (this work)	Prior Value
Kapton	2.89 ± .06	3.00**
PTFE (or FEP)	0.37 ± .06	0.1 – 0.5
polyethylene	3.97 ± .23	3.32 – 3.74
PMMA	6.3 ± 0.3	4.91*
PMMA		3.14
polystyrene	4.17 ± .17	1.7
Carbon; (HOPG)	1.04	0.6*
Carbon; pyrolytic polycrystalline	0.61	0.58

* Indicates UAH measurement on STS-8. Other values are from tabulations of others' data by JSC and LeRC.

** Error not quoted, may be 10-20%.

† Erosion yields for LDEF are based on a preliminary fluence of 9.0×10^{21} atoms cm⁻².

Summary

In general, agreement is reasonably good between erosion rates from the UAH LDEF experiment and prior data obtained at much lower mission fluences. Agreement is particularly satisfying in the case of Kapton where the prior database is large.

We note that, in spite of the known presence of silicaceous contamination on LDEF surfaces, the erosion rates of the highly erodible materials are hardly affected, if at all.

Caution is needed in comparing profilometry data (all UAH data is of this type) with weight-loss data. In profilometry we establish a ground-level of unimpeded erosion and ignore pinnacles and mesas where the material may have been protected by some foreign material.

We do not understand the difference between our own values of erosion for HOPG graphite on STS-8 and LDEF.

CHANGES IN OPTICAL PROPERTIES OF METAL FILMS EXPOSED ON LDEF

University of Alabama Experiment A0114

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- **Metals:**

Nickel	~400Å
Gold	350Å
Niobium	300Å + 100Å
Iridium	300Å
- All sputtered films on optical quality fused silica substrates
- No interface binder coating used
- All films partially transmitting at visible wavelengths

Measurements included in this discussion:

Reflectance over the wavelength region 250 - 2500 nm

Transmittance at 4 wavelengths in the visible

Stylus profilometry (Ir)

Optical microscopy (Ir)

LDEF Exposure (6 yrs) Materials List A0114

Metal Films

Ag
Au
Au on C
Sn
W
Pt
Os
Ir
Au on Ag
Ge
Cu
Ta
Nb
Mo
Mg
Au on Nb
Ni

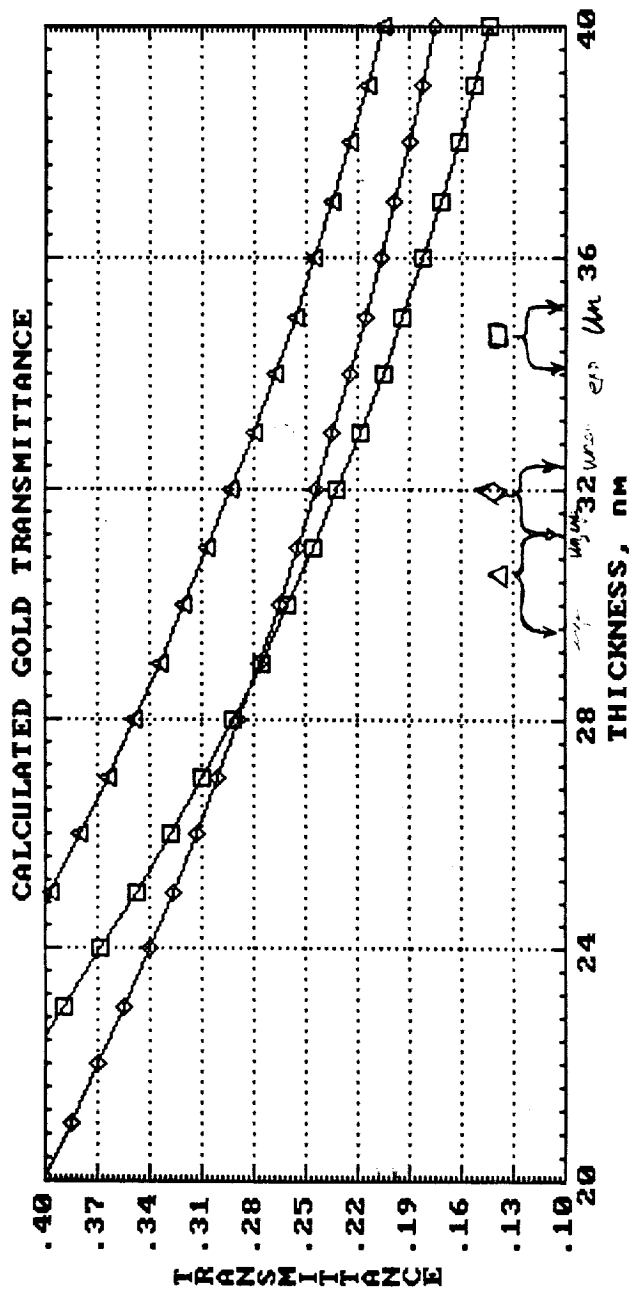
**Non-metals
(solid flats)**

C
Si
Ge
C (single crystal)

SiC
MgF₂
BaF₂
CaF₂
LiF
WC

Polymers

Lucite
PVT
Kapton
Mylar
Teflon
Nylon
Polystyrene

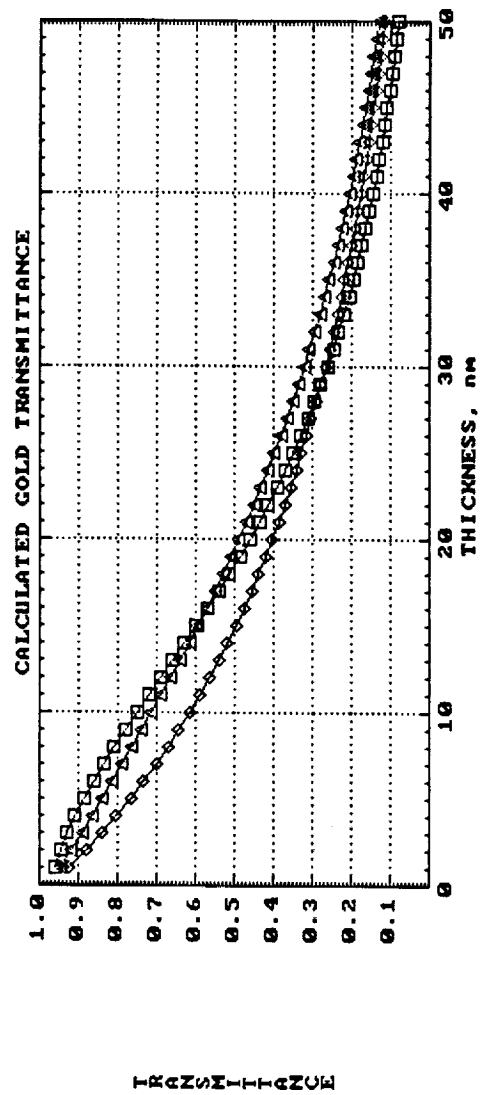


$\sim 316 \text{ \AA}$
 stylus in unexp. area
 $\sim 350 \text{ \AA}$
 stylus in exposed area (suggests $\sim 35 \text{ \AA}$ contaminant or swelling).

$\square \Delta L_0 = 653 \text{ nm}$ $\Delta L_0 = 517 \text{ nm}$ $\diamond \Delta L_0 = 477 \text{ nm}$

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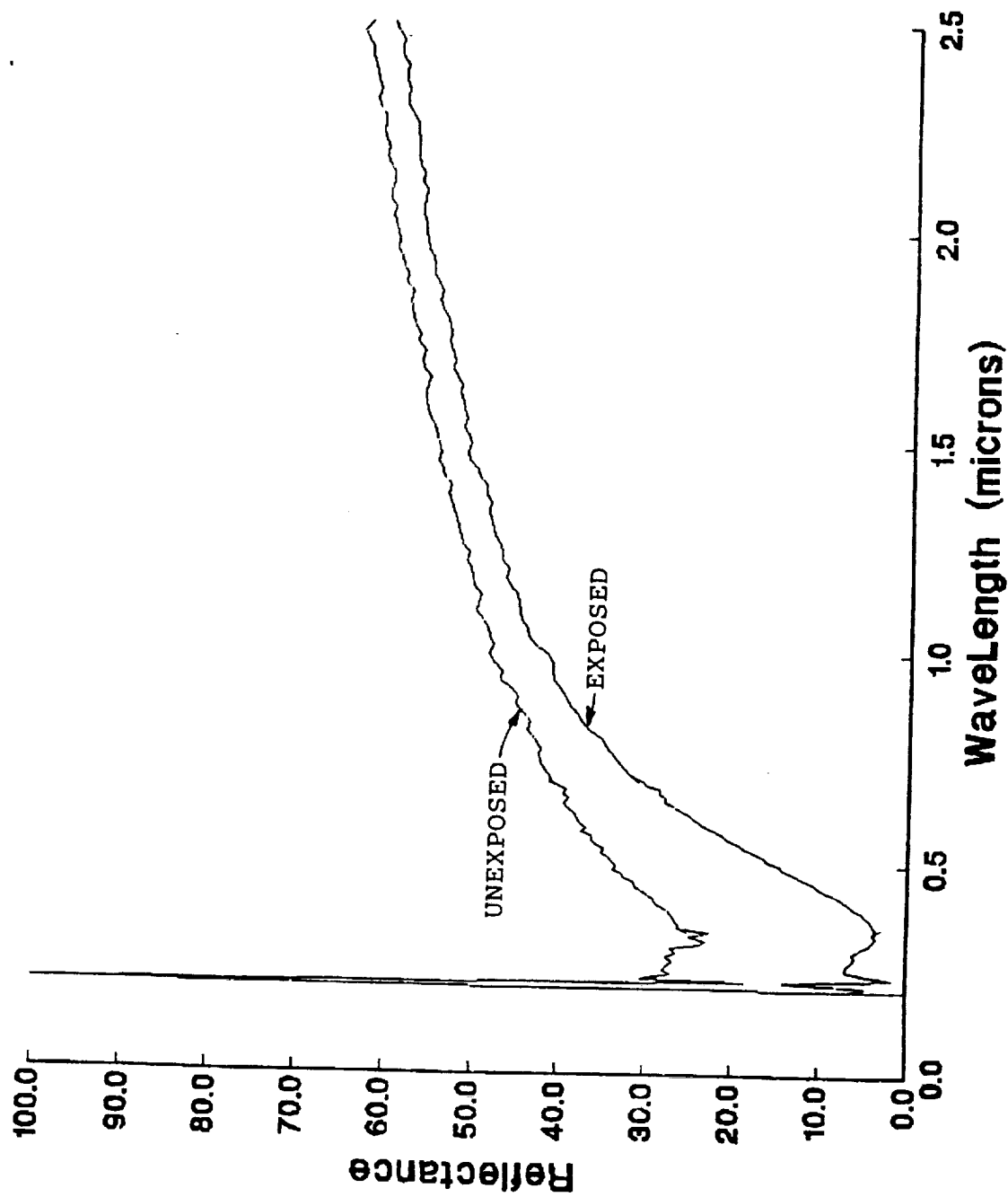
Measured change in T in:
 Red
 green
 blue
 equivalent thickness change unexp. area:
 -10 Å
 -17 Å
 -12 Å (average -13 Å)



□ LO=653 nm
Δ LO=517 nm
◇ LO=477 nm

A0114 ①

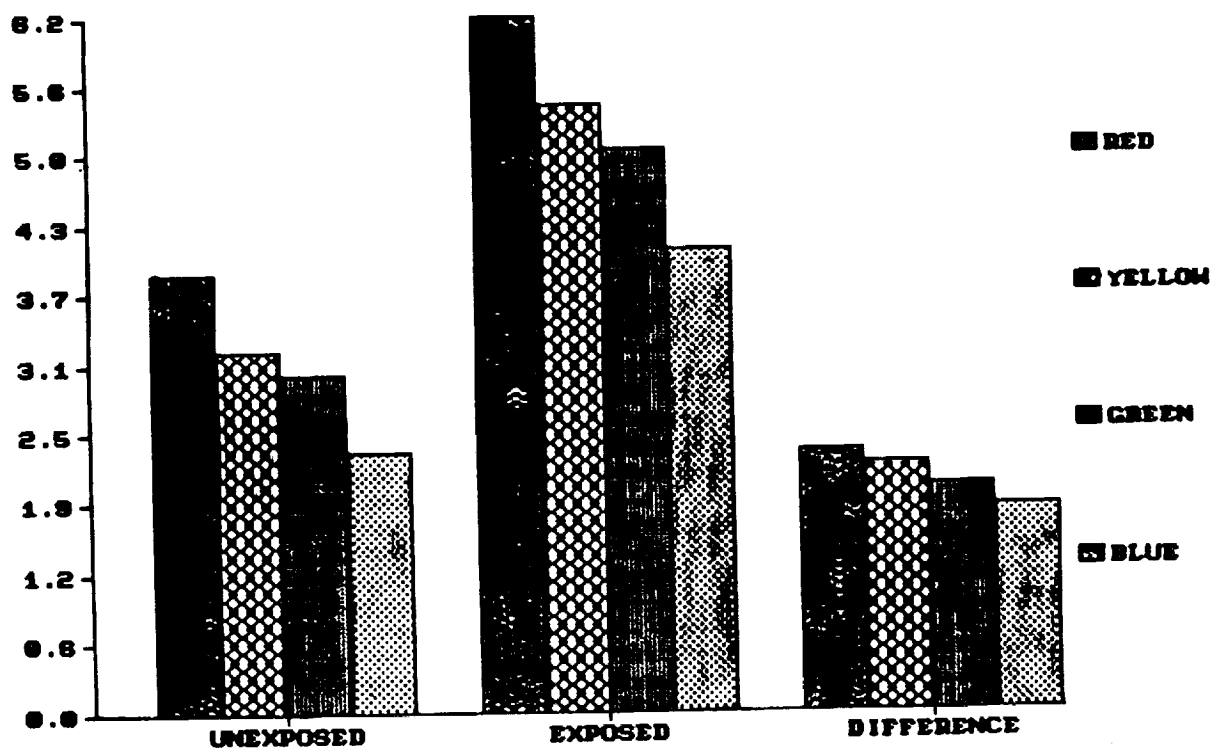
LDEF, A0114, C9-45, Ni FILM, % REFLECTANCE



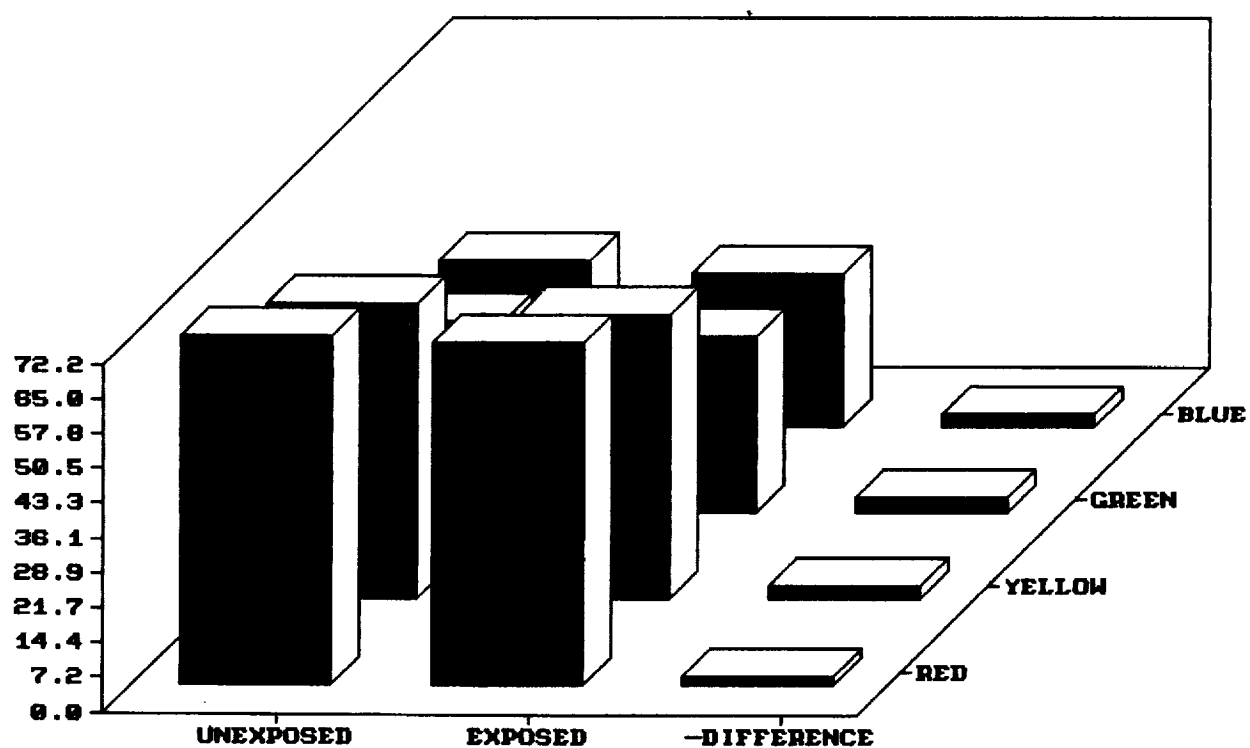
LDEF, A0114, C9-45, Ni FILM, REFLECTANCE (PERCENT)



LDEF, A0114, C9-45, Ni FILM, TRANSMITTANCE (PERCENT)

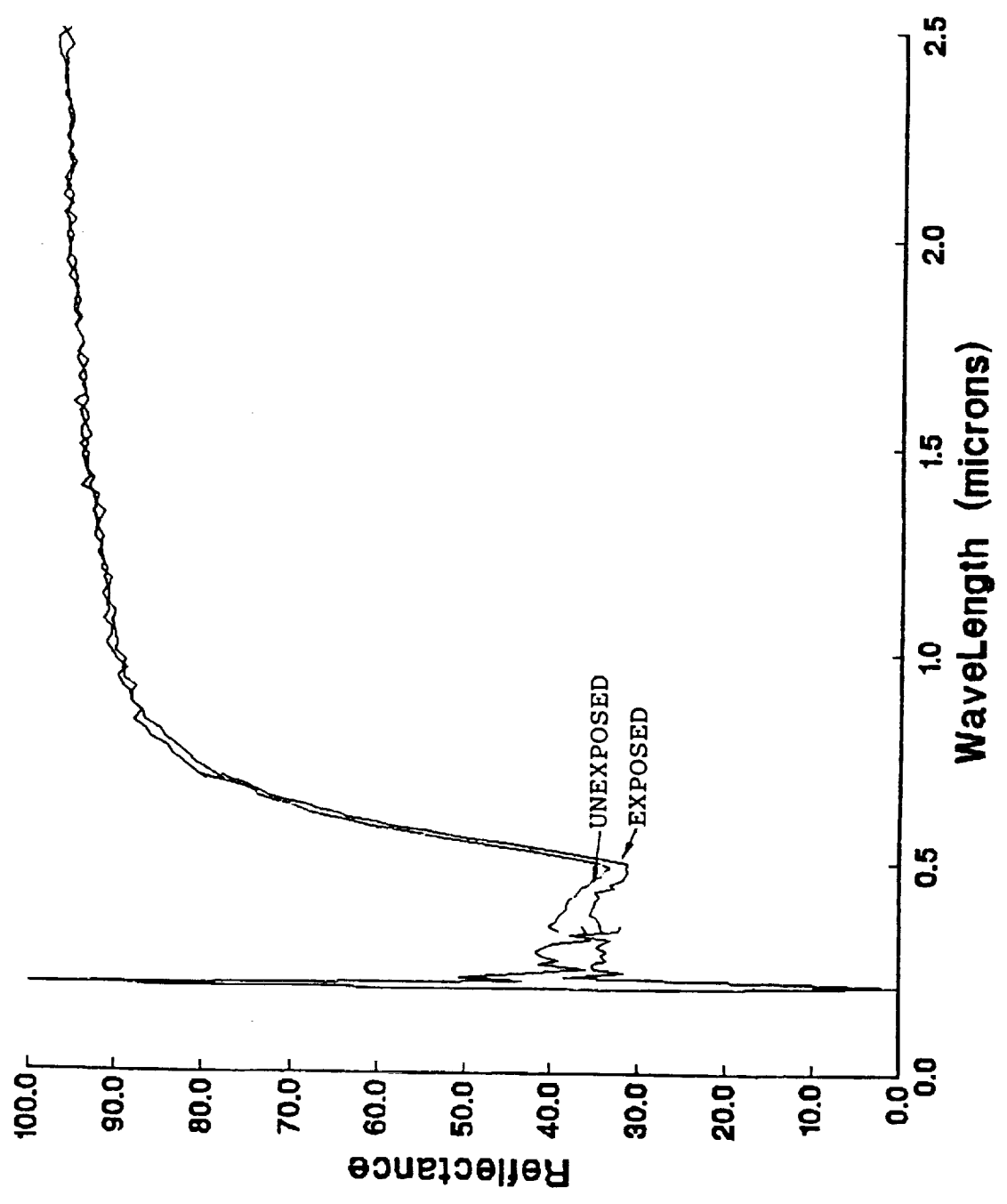


LDEF, A0114, C9-46, A_u FILM, REFLECTANCE (PERCENT)

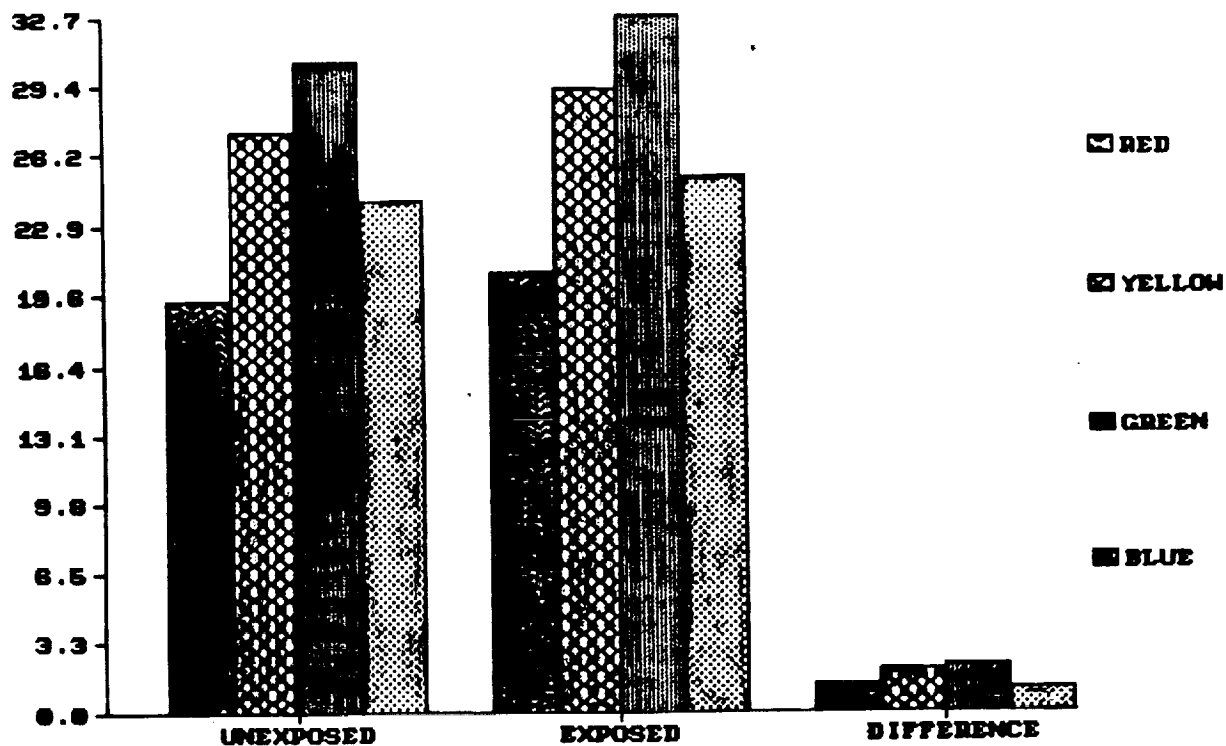


A114 (3)

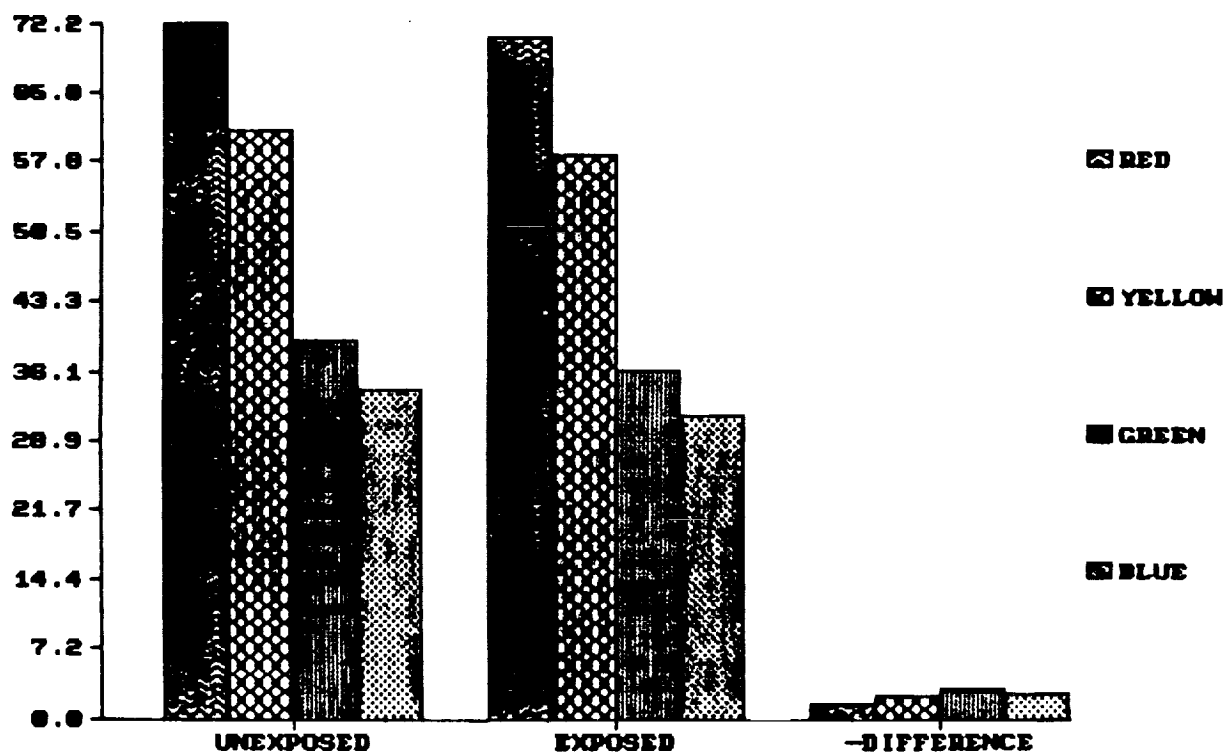
LDEF, A0114, C9-46, Au FILM, % REFLECTANCE



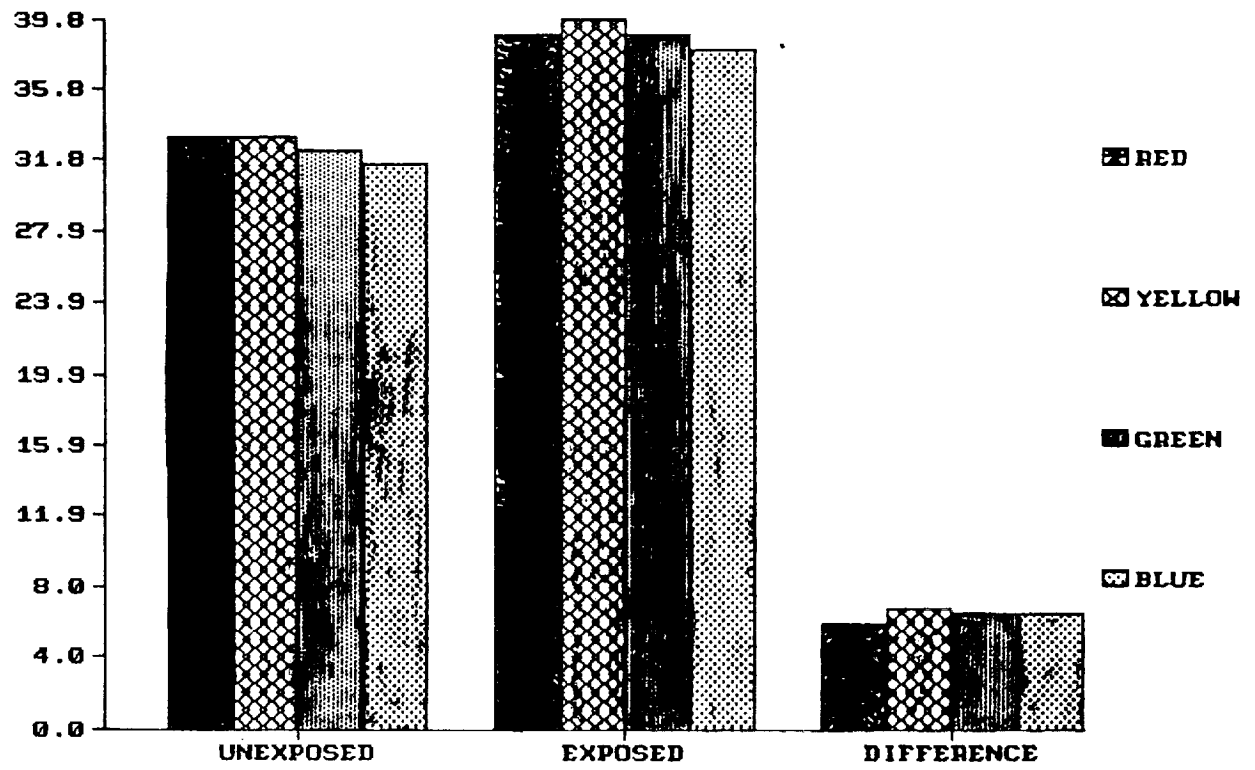
LDEF, A0114, C9-46, Au FILM, TRANSMITTANCE (PERCENT)



LDEF, A0114, C9-46, Au FILM, REFLECTANCE (PERCENT)

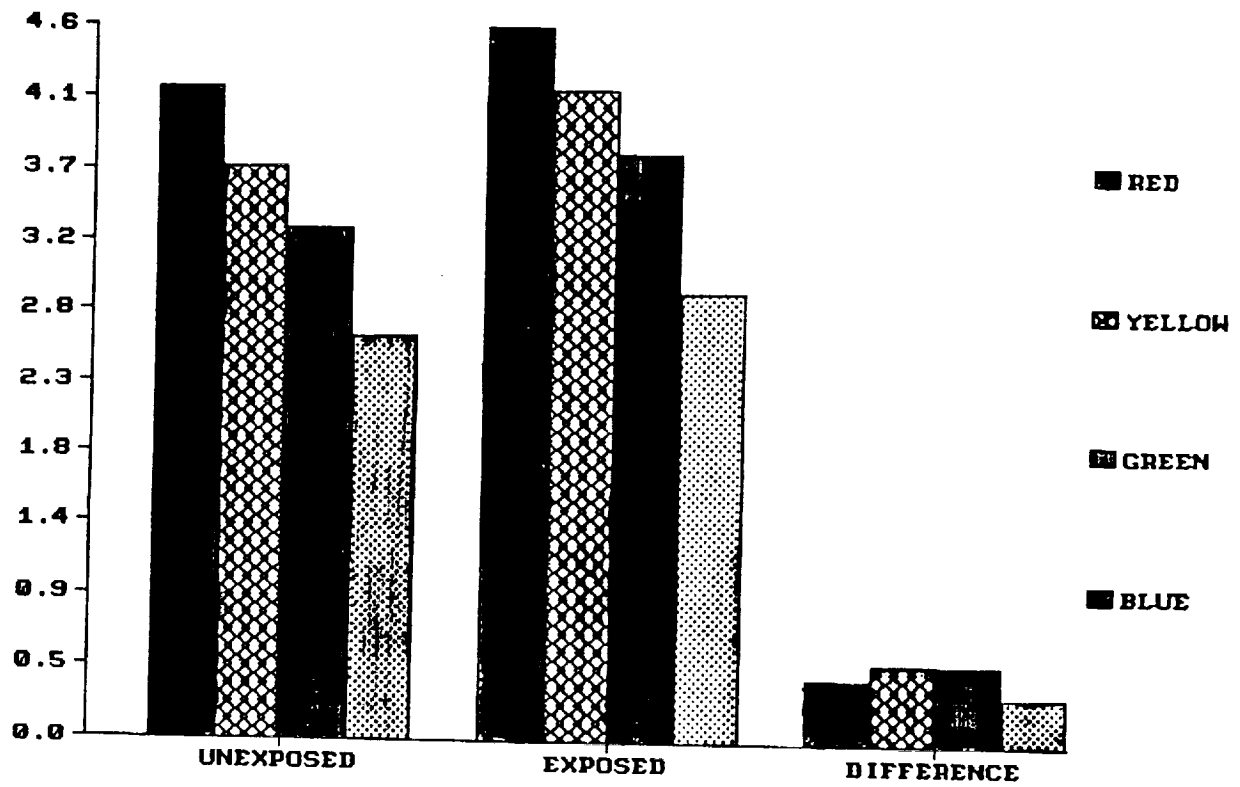


LDEF, AC114, C9-22, 100 A Nb Film, TRANSMITTANCE (%)

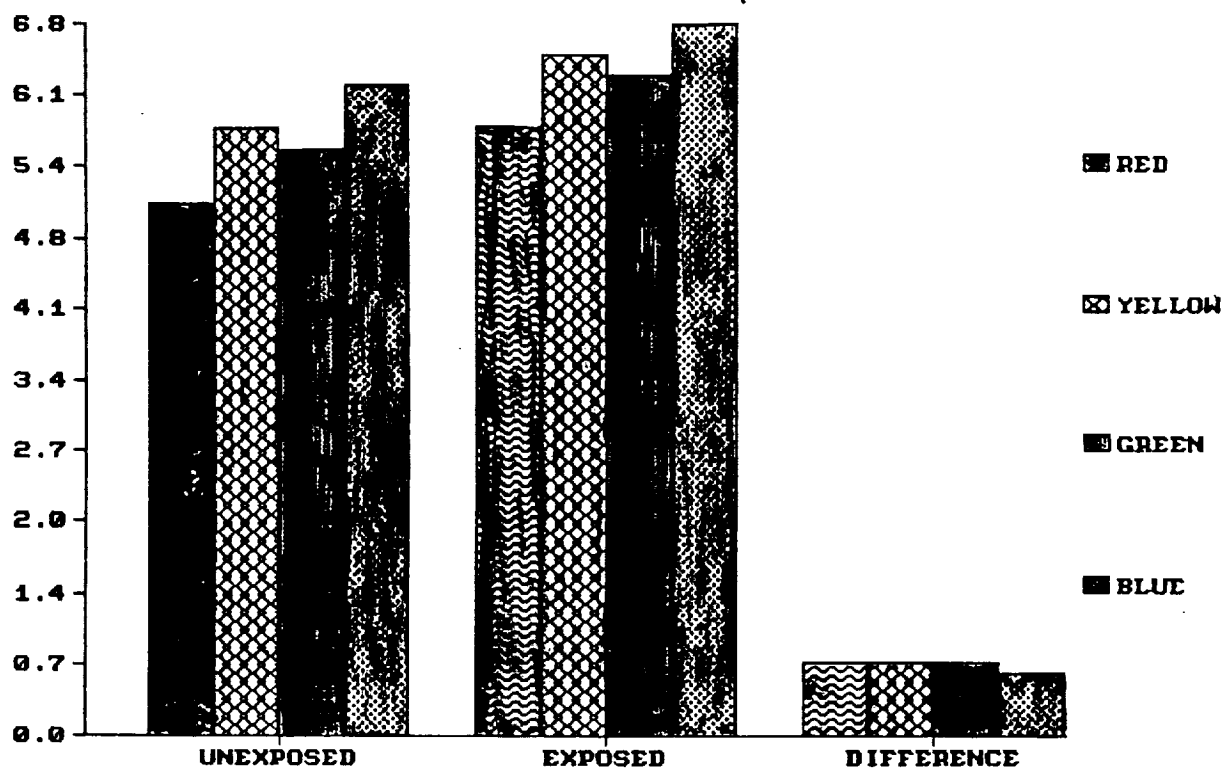


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LDEF, A0114, C9-22, 800 A Nb Film, TRANSMITTANCE (%)



LDEF, A0114, C9-12, I- FILM, TRANSMITTANCE (PERCENT)



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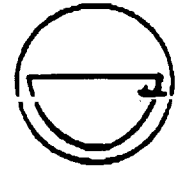
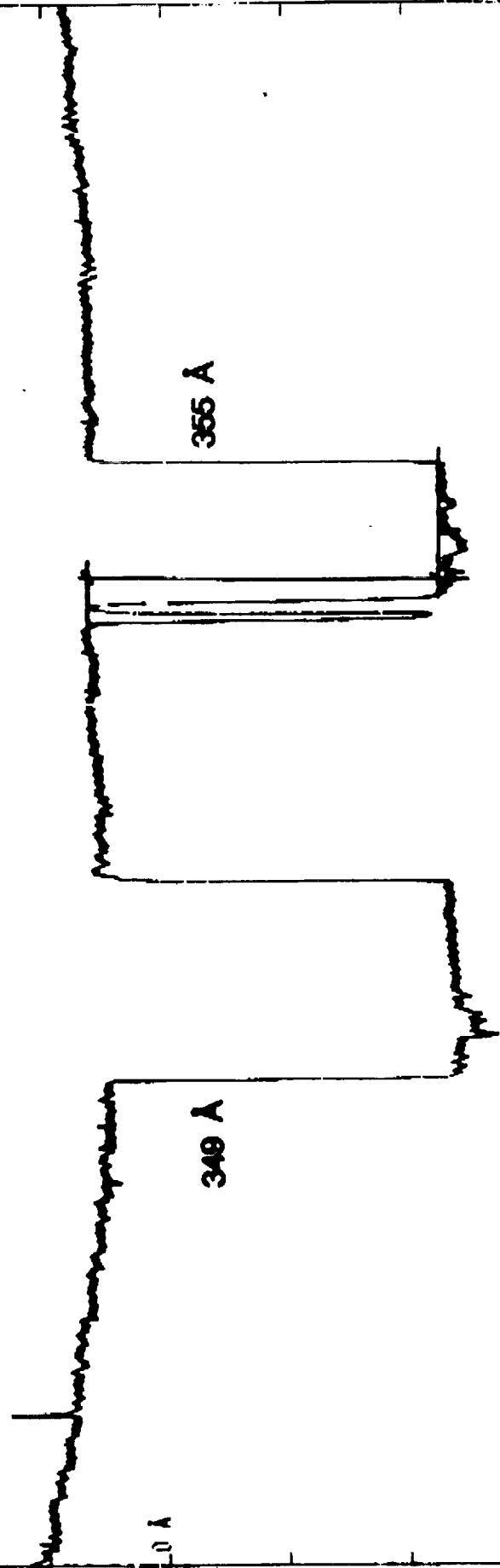
1 Micron Stylus Radius
1 Mg Stylus Loading

Au film (C9-46)
Exposed Area

40.5 Å

157.5 Å RMS Roughness

125 Å



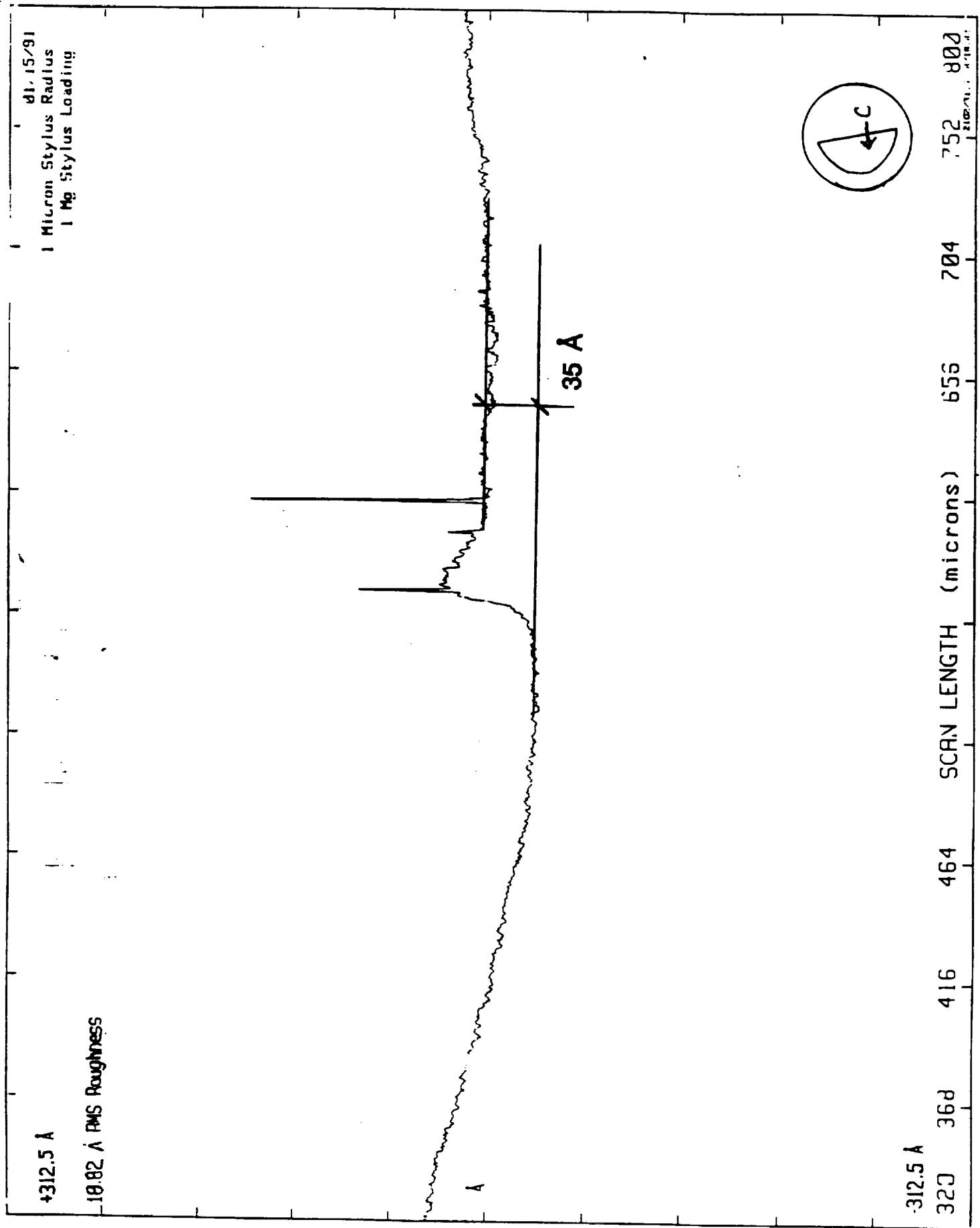
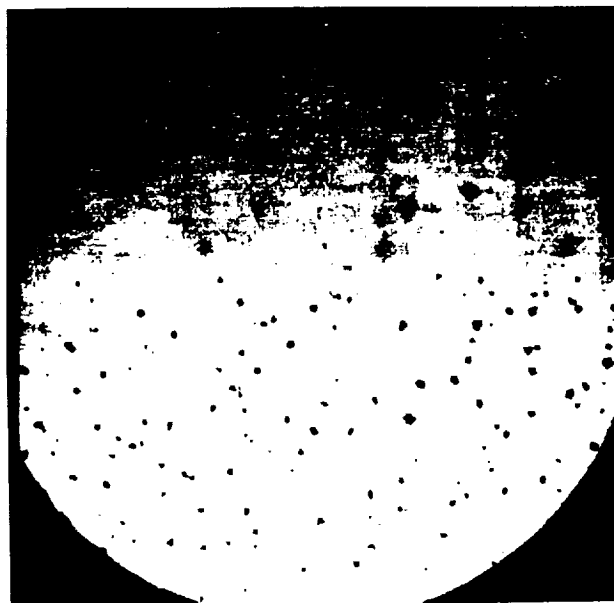
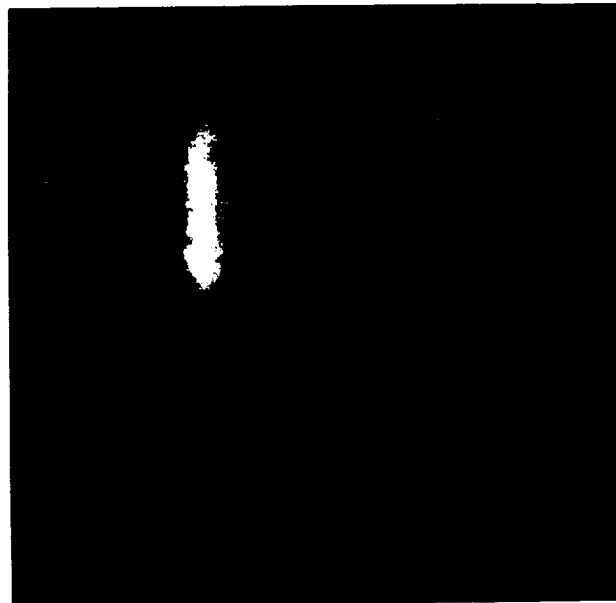


Figure 4. Surface profile of transition from unexposed to exposed of Iridium film

1 mm

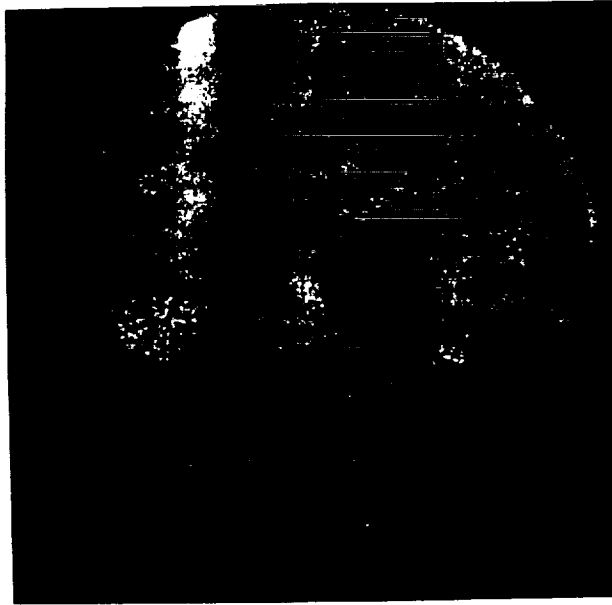


11-15-91
Ir Film, 11-15-91
unexposed



LDEF, A0114, Ir Film, 11-15-91
~1 μ m lines (wide) in debonded
structure in exposed area.

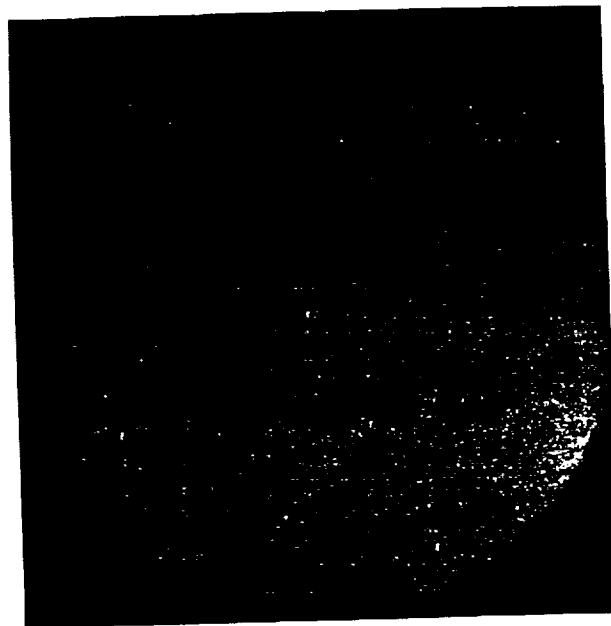
100 μ m



LDEF, A0114, Ir Film, 11-15-91
~1 μ m wide lines in debonded
film in exposed area.



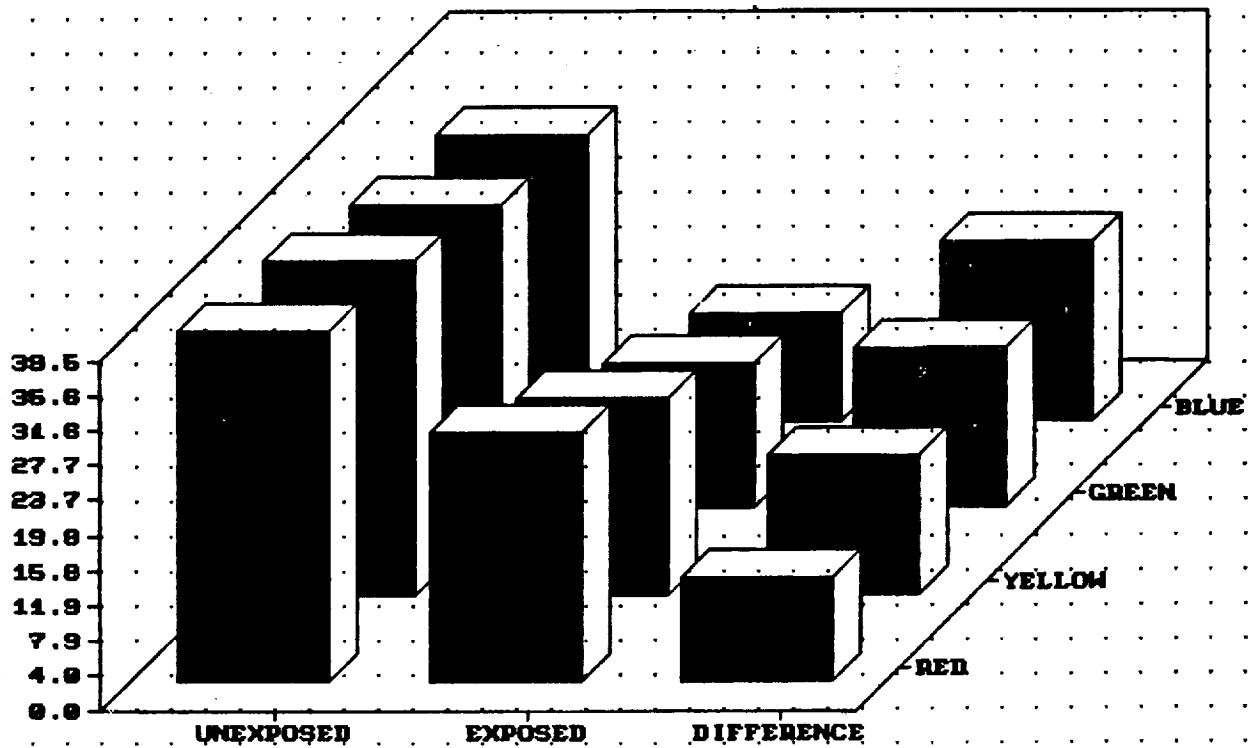
LDEF, A0114, Ir Film, 11-15-91
EXPOSED | UNEXPOSED



LDEF, A0114, Ir Film, 11-15-91
~ 1 mm wide lines in debossed
film in exposed area.

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LDEF, A0114, C9-45, Ni FILM, REFLECTANCE (PERCENT)



LDEF, A0114, C9-45, Ni FILM, TRANSMITTANCE (PERCENT)

